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REPORT OF

ALBERT F. NOYES, CITY ENGINEER

AND

EDWARD A. BUSS, C. E.,

ON PLAN FOR

SURFACE DRAINAGE

FOR THE

CITY OF NEWTON, MASS.

DEC. 12, 1892.

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REPORT OF THE CITY ENGINEER
AND EDWARD A. BUSS, C. E.,

ON PLAN FOR

SURFACE DRAINAGE FOR THE CITY OF NEWTON.

OFFICE OF THE CITY ENGINEER,
WEST NEWTON, Dec. 12, 1892.

To His Honor the Mayor and the City Council of the City of Newton:

GENTLEMEN.—In accordance with order (No. 11680) of the City Council, under date of June 24, 1889; "that the City Engineer be requested to make additional surveys, and submit as soon as possible, detail sewer plans for surface and house drainage," this report with the plans and profiles accompanying it is herewith respectfully submitted. It is intended to cover in outline the various questions arising in connection with the surface drainage for the City of Newton.

Immediately upon the passage of the order, work was begun. Topographical maps of the city showing the elevation and change in level of most of the streets, streams, brooks, etc., were made, and a study of a system of sewerage and drainage was begun.

The execution of the large amount of extra work ordered by the City Council of the City Engineer's Department, demanded all of the office room, and the service of such help as was available.

Finding I could obtain the services of Mr. Edward A. Buss, a Civil Engineer, now of Boston, but formerly associated with this office as assistant, I deemed the best interests of the City could be served by retaining his services to assist in making the plans and study of both of the questions to be considered.

As the study of the two questions progressed, it became evident that, that portion relating to surface drainage presented so many complex problems, their solution would take a longer time than was anticipated, and as it became necessary to submit the plans and report on the house drainage system at an early date, the study of this portion of the question was continued only so far as the two questions could be carried on to advantage together.

The report and plans for the house drainage system was submitted to the City Council Dec. 6, 1890. As soon as practicable after submitting said report, work on the plans for the surface drainage system was resumed, and the report which is now submitted is the result of the study as made by Mr. Edward A. Buss, in conjunction with the City Engineer, and is their joint report.

System of Drainage.

Before describing the system proposed, we take the liberty to refer to the report on house drainage, in referring to the methods of drainage usually adopted, which may be sub-divided, or classed as surface, house, and sub-drainage.

"SURFACE DRAINAGE should provide ample channels for taking the water which falls upon the surface of the ground, thereby preventing the flooding of land upon which dwellings have been built, and for draining lands which would otherwise be wet and unhealthy. It should also provide for taking the water by underground channels, from the streets at frequent intervals, thereby preventing the excessive washing of the surface, and effecting a saving in the cost of their maintenance.

HOUSE DRAINAGE, or what is commonly spoken of as sewerage, should provide for taking all waste or drainage from the buildings and conveying it rapidly to some point of discharge, before putrification has taken place.

SUB-DRAINAGE should provide channels for conveying and lowering the ground water, thereby preventing the annoyance of wet basements, and by the presence of air in the soil, accomplishing its purification, and increasing the healthfulness of the dwelling-houses."

Former Systems.

The system of sewers in use until within a few years in most cities, was intended to cover the three questions which are being treated separately in Newton, and the consequence was, that a sewer must be placed deep enough to lower the ground water, made large enough to carry the storm flow without backing into the house connections, be of such form as should permit of ready inspection, and provide for a thorough cleansing during the periods of dry flow. The result of this attempt to accomplish three antagonistic results by means of one system of channels, was in too many cases a sewer that was too high, too small, and not self-cleansing.

House and Sub-drainage.

In many portions of the city the water is retained in the ground at so high a level as to make difficult, if not impossible, the construction of a water-tight system of sewers, (which for reasons explained in the report of the City Engineer to the City Council under date of Dec. 6, 1890, was necessary in the City of Newton), without first laying sub-drains at a lower level than the sewer, to carry off the ground water during construction, and by its infiltration in the open joints of the pipe to permanently maintain the ground water at so low a level in the vicinity of the sewer as to prevent external water pressure.

By providing inlets in the sub-drain, and laying sub-drains to the basements of houses, where necessary, they can be made dry and healthy. The system of house and sub-drainage adopted, and which is being constructed, contemplates the laying of sewers to take the sewage or waste from houses only, and sub-drains laid at a lower level than the sewer to take the ground water, and removes two of the questions, leaving simply a question of providing water-ways of sufficient capacity to carry off all the rainfall necessary to avoid flooding the streets or private grounds.

Requirements.

It is no longer necessary to provide for carrying this quantity in the lower half of the drain, as there are no house connections entering it. It can be considered as a gravity main for conveying a certain amount of water which increases as each catch-basin or branch is passed, and the only limiting condition is that the water shall not overflow at the catch-basins or manholes, so that if necessary the drain may be run under a slight pressure, and thus avoid using large sizes when entering upon a section having a low grade.

It is no longer necessary to exercise the same care as formerly in selecting a suitable shape of channel for the dry weather flow, and in many portions of the system the flow through the drains will entirely cease as soon as the flow ceases in the gutters. In other cases there will still continue to be a flow of ground water, which has been collected by the underground drains and discharged into this main drain.

It is no longer necessary to provide a thoroughly water-tight drain along the whole length, as there is no objection to a reasonable amount of leakage into or out of the drain. The amount that is permissible varies with the location and height of the drain relative to the adjoining property. Under the old system, the standard sewer was of brick or pipe, waterproofed in the most thorough manner to avoid the contamination of the soil by the sewerage which leaked out through the joints.

It is no longer necessary to provide so carefully for the self-cleansing of the drains, to prevent their becoming foul during periods of minimum flow, as the flow at that time is no longer objectionable.

New Problem.

On account of these reasons, there is a larger variety of the problems to be met and settled before reaching the design of greatest economy, although the expense of construction is reduced very decidedly below that which was needed under the old system. It is no longer simply a question of whether the city can afford to pay at the present time for a brick main drain of a certain diameter, but becomes one where, under varying circumstances, open channels, stone drains or brick drains may be employed. A few general rules indicate what will usually be the best construction on the question of economy and utility.

Saving to Land Owners.

In the construction of the main line through the valleys forming the thread of the different water sheds, it is desirable to provide for as low an elevation of the water surface as is practicable within reasonable cost, as the height of this maximum surface is the limit for the grade on each of the branch lines that enter it, and a little extra expenditure to procure one or two feet more in depth on the main line may result in a large reduction in the expenditure for the branches that enter from the side territory.

In order to accomplish this lowering of the water surface on the main line, it is necessary to resort to different methods according to whether the drain is placed in the street or on private ground, and also according to whether the land damages by a taking would be excessive or reasonable.

There is quite a large portion of the city where the land in the vicinity of the main drain is now held at a very low figure, and is worth but little on account of being flowed during quite a portion of the year. This land cannot be made available for building without doing one of two things: either the channel of the brook must be lowered, or else the entire surface of the section must be raised so as to provide for cellars, etc., above the freshet level of the brook.

The usual custom in the past in the great majority of cases has been to grade up the lots in such a way as to raise them above the freshet line of the brook, and in too many cases economy has caused the building of houses at so low a level that the cellars are frequently flowed, or at least made damp by the rise in the drain or ditch. Economy to all concerned would call for the lowering of the brook, as a short consideration of the question will show.

If we assume a width of fifteen feet as necessary for the construction of the main drain through any valley, we have fifteen cubic feet of excavation required for each additional foot of depth. This would cost at a maximum figure of seventy cents a cubic yard in wet ground, or about thirty-nine cents per linear foot. If grading is substituted for the lowering of the channel, we will find that at twenty cents a cubic yard, this thirty-nine cents would only grade a section fifty feet wide, and as soon as the width of the valley increases beyond this amount, the difference in favor of the lowering of the channel becomes more marked.

There are many places in Newton where it would be necessary to grade up for a width of at least 500 feet, in order to bring the land high enough above the waterway to enable its use for building purposes, unless we resort to the other plan of deepening the channel; 500 feet in width would require eighteen cubic yards for each foot, or at twenty cents per cubic yard, $3.60 for each foot in length of the valley, but the excavation can be made for about forty cents per foot, making a difference in favor of the excavation of about $3.00 a running foot on this width of valley. The practical reason why this is not resorted to in more cases, is the difficulty of arranging for concerted action by the land owners of the various estates affected by the change, and the fact that it is difficult to reconcile the land owners to an assessment by the city for benefit derived from improved drainage, and they frequently pay a contractor $100 more cheerfully for grading up this property, than they would pay the city $25, as their share towards the uniform drainage of the whole valley.

This brings up one of the features of the assessment question, which will be considered with other items later. It will be seen however, that a large gain results to the owners of adjacent property from comparatively a small expenditure in the main drain.

This placing of the main drain in the valley at a low level affords an outlet for the subsoil drains without being carried too far, and requiring too large a size for them.

Style of Construction.

The next question relative to these principal waterways, is as to the form of construction to be adopted. For a waterway of 100 sq. feet, it will be necessary to provide a brick drain over eleven feet in diameter, and the same section can be obtained by means of an earth channel twenty feet wide, and five feet deep, or to allow for difference in friction, say twenty-five feet wide, and five feet deep.

The brick drain cannot be built for less than $20 per linear foot. The open drain costs from $3, to $10 per running foot, and has a further advantage that it is not necessary to do the entire construction at once, but it may be improved and deepened as required, say once in five years, without the large interest account which would be required for the eleven foot drain, if constructed at first, and without the laying aside the old construction if any smaller size was introduced temporarily. The brick drain would cost $100,000 per mile, while the open construction would be $16,000 to $50,000 per mile, making a difference on the interest account in favor of the open channel of $2,000 to $4,000 per annum for each mile in length.

Parkways and Rights of Way.

The principal objection to the open drain has been due to the fact that it is usually laid out through private grounds, and becomes a receptacle for all of the surplus accumulations of the neighborhood. To obviate this objection, which is surely a strong one, it is recommended that portions along the line of the principal waterways, should be taken and controlled by the city where the topography and development of the territory will permit, the sections serving as parkways as well as for drainage purposes, and also that on other portions plans be made and filed, defining the existing water-courses, and the locations, etc., for future water-courses where it is not desirable to attempt full control of the property by the city.

The parks recommended should be at least wide enough to furnish roadways, and an ample channel for the water, with enough of grassland to take away the utilitarian appearance.

Newton has the topography which will permit the building of parks to unusual advantage, and a large portion of the present valleys can be easily adapted for this purpose, forming the basis for a chain of parks between the different villages, and the remaining land would immediately change in value from poor meadow lands to first-class building sites, which would be made accessible by expansion of the systems of electric street railways.

There is no movement that can be made which would return such immediate and lasting advantages to the city, as the construction of these parks and waterways, and it would also add very decidedly to the attractiveness and health of the city.

To show this question graphically, a plan has been made, showing the approximate outlines of the portions which may now be considered as poorly drained. This does not refer to the present conditions, but includes sections which will be subject to annoyance as soon as the development in the upper part of the water shed increases the flow in the drains and brooks. These sections can be reclaimed by a reasonable expense compared with the resulting advantages. After providing for building and protecting these parks and waterways, a large portion of the difficulty connected with maintaining an open channel has been obviated. It is no longer the receptacle for rubbish, it can be deepened and improved as desired from time to time without the constant expense of land damages, and what was formerly a detriment to the section has become one of the chief advantages.

The use of these methods would change practically the whole of these low sections to portions available for residence. The park method is not practicable through the compactly settled villages, but is available for nearly the entire length of the other portions of the main villages. Where it is not available, rights should be defined or acquired for entering upon the properties for the purpose of construction and the increased size of waterway, provided from time to time with either brick or stone construction.

Branches.

The branch waterways naturally divide themselves into two classes: one class consists of those which now have a definite course across private property, while the others are those which must be provided in the future, in order to take care of the collection from the upper parts of the water shed which now flows over the surface, but not in a well-defined channel.

Capacity.

The question may be asked, why it is necessary to provide in any way for a future drain, say five or ten times as large as the one that has apparently answered for the requirements.

The answer is the fact that the collection from the water-sheds increases with every change that is made from the natural condition of rough soil, narrow channels, and large swampy sections. Each house that is built, each lawn that is graded, each channel that is deepened or straightened, increases the rate of flow during, and after rains.

There are sections in Newton where the present overflow from the valley rarely reaches a rate of one-half inch per hour over the entire section, but recent gaugings and the experience of other cities have shown that it is advisable to provide for a collection of not less than two inches per hour with the drains running full, that is carrying the full amount for which they are intended.

Sizes.

The sizes shown on the drawings submitted as the outlines for surface drainage work, are based upon the expected collection from the different water-sheds, varying from an allowance of two inches in depth over the water-shed for a small area to 3-10 inches of depth per hour at the lower end of the Laundry Brook, which is the largest area in the city. The time at which it will be necessary to enlarge the channels to the sizes shown is a matter of judgment, and can only be determined at the time the demand for construction arises. In many cases, three or even four enlargements would be more economical than a single change provided the material used is such as to permit the enlargement without destroying or throwing aside the previous work.

This is one of the advantages of the open channel system, as additional excavation can be made in successive years at approximately the same expense as would be required if all done in a single year, provided care is taken to provide depth, rather than width in the early excavations.

Route.

The description which follows of the water-shed and the treatment, should be regarded as a recommendation for the general method to be pursued, rather than a distinct outline of the exact course. The question of material, land damages, rights of way, time of development, preference of owners, and other points all entering into the question, and are of sufficient importance to prevent any attempt to furnish more than an outline of the scheme.

Water-sheds and Treatment.

For the purpose of studying the drainage, the city naturally divides itself into eleven sections:

1st, The Hyde Brook section.
2nd, The Lower Charles River section.
3rd, The Middle Charles River section.
4th, The Upper Charles River Section.
5th. The Laundry Brook section.
6th, The Hammond Brook section.
7th, The Cold Spring Brook section.
8th, The Lower Cheese Cake Brook section.
9th, The Upper Cheese Cake Brook section.
10th, The South Meadow Brook section.
11th, The Boston section.

The decision of the separation of grade crossings of the Boston and Albany railroad, may change the treatment which it would be desirable to make of the Hyde Brook, Laundry Brook, and Cheese Cake Brook sections, and the decision as to said treatment should not be made until the railroad question is settled.

Hyde Brook Section.

This section includes the larger part of the Wards one and seven, and is bounded by a water-shed line close to the following streets; commencing at the easterly side of the valley: St. James St., Washington St., Boston Line, Kendrick St., Waverley Ave., Cotton St., Park Ave., Centre St., Mt. Ida St., Washington St., Hovey St., Jewett St., and the Watertown Line.

The outlet for the system is through Hyde Brook, between Nonantum Street and Nonantum Place to Charles River. At the corner of Brook and Elmwood Streets, the drain divides into two branches. The westerly one is from Elmwood and Centre Streets, and receives a portion of the water-shed above Franklin Street by a connection with the other branch at that point.

The westerly branch passes through Elmwood and Eldredge Streets to Franklin Street, thence to Park Avenue, receiving its principal branch near Vernon Street, where the water from the Tremont Street valley enters it.

All of these drains below Franklin Street on the main line and below Waverley Avenue on the Tremont Street branch, must be constructed of material suitable for streets and for private lands where tight drains are needed.

As the grades are nearly flat, it is advisable to use brick construction to ensure smoothness in the waterways, and secure the highest flow for a given size of channel.

The upper portion of the valley above Franklin street, is now drained by an open channel extending to Sargent

Street. This channel has an ample fall and can be made of sufficient capacity by excavation to serve for the final requirements of the section without resorting to the use of the covered channel.

The right of drainage is already established, and probably the land damages to meet any requirements for future enlargement would be normal, if a parkway or roadway was laid out before other changes were made. The easterly branch of Tremont Street line, passes through a section between Park Street and Waverley Avenue. The section would be greatly benefitted by a deepening of the channel, and the final construction should be of brick. The land is too valuable and too close to the station to remain permanently in its present condition and would be brought into the market at less expense by lowering the drain than would be required for grading up above the present water table.

The portion of this branch above Waverley Avenue is through a section where the water lies close to the surface during a large portion of the year, and it would be immediately improved by means of a lower channel for the water. This section has been decidedly improved by the sub-soil drainage being placed in connection with the house sewers, and needs but small additional expense to complete the required improvement.

Lower Charles River Section.

This section includes small portions lying close to the river and their treatment involves no special problems. The portion near the Boston line is easily drained, directly to tide water. The portion near the Boyd Street section has been treated in connection with Watertown, and the existing construction is ample for a number of years; although smaller than the calculated capacity.

The Nonantum section can best be provided for by a deepening and improvement of the Brook from Chapel Street to the Watertown Line, in connection with the improvements needed for the Nonantum Worsted Company.

The section at California Street and Bridge Street will be treated as found necessary in the future, the layout depending upon new streets and other questions.

Middle Charles River Section.

This includes the portions of Wards 4 and 5 between Waltham Line and the Newton Pumping Station at Newton Upper Falls. This portion has two valleys of fair extent, the remainder being usually cared for by short branches, discharging directly into the river and without connection with each other. The first valley is one at Grove and Washington Streets, near the Circuit Railroad. This can be treated by means of an open channel and a parkway can be laid out through this section and connected with a river drive which may be built in the near future.

The other valley is at Chestnut Street near the Circuit Railroad. There is a pond at the lower end of this brook which does not at present interfere materially with the drainage, and a waterway can be secured and preserved with a small present outlay for right of way.

Banks of the Charles River.

The shores of the Charles River both on the side nearest Newton and on the opposite side which lies in the towns of Weston and Needham have for a considerable portion of their length a margin of low land lying between the present high and low water marks. Attention has been called to the question of the effect of the public health of these sections, and it has been deemed proper to include the suggestions in this report as long as they are of the same general nature as the improvements recommended for other parts of the city.

Treatment.

The treatment that can be adopted is two-fold. A portion of the trouble can be remedied by legislation or agreement with the mill owners, and another portion can be remedied or greatly mitigated by improvements made in connection with the parkway along portions of the bank, and in other sections in such a way as to improve the adjoining property.

The problem is practically solved when the surfaces that are exposed by the rise and fall of the river have reasonably sharp slopes and free from any considerable quantity of decaying matter. It would be beyond the province of the city to attempt complete treatment in this respect, as that can only be accomplished by a systematic walling or rip-rapping of the banks from one end of the city to the other along the water front, and the removal of all exposed surfaces away from the bank. Even then only one-half of the question is covered, as the nuisance complained of at present is about equally due to the state of affairs on the two sides of the river.

Legislation or Agreement.

The question of the control of the water surface in rivers has always been a fruitful cause of litigation due in most cases to the fact that the two interests involved are effected differently by proposed changes and are necessarily antagonistic.

In the present case, however, arrangements should be consumated by which the effect on the public health would be greatly improved without injury to the interests of the mill owners.

The present practise along the river is to draw the water down during the dry times to quite a considerable distance below the legal height at which the companies can maintain it. The first few inches of this draft is of advantage to the company. The advantage ceases, and loss commences just as quick as the river is drawn down during the working hours to such a height that it does not recover to the top of the flash boards through the night. The reason for this is the fact that as soon as the river is drawn down, the available head at the wheels diminishes and the power resulting from the use of water also diminishes. The gain in the first few inches of draft is due to the application of the water which otherwise would remain in the pond and escape at night over the dam. Loss results, however, as soon as the pond is drawn low enough so that it does not fully recover during the night.

The drainage area above the Waltham dam is approximately 190 square miles after deducting about sixty square miles for the area diverted through Mother Brook. The yield for the four driest months of the year would not exceed one-half of one cubic foot per second for each square mile of drainage area; this amounts to 4,400,000 cubic feet for thirteen hours of night flow, without making any reduction for the reduced flow due to the storage above Newton Lower Falls.

The greatest drawing down that is of any advantage at the Waltham Mill is the depth required to store this flow for use during the next day, or about seven inches. If we should fix a standard of one foot below the top of the flash boards, we have made ample provision for the night storage and the slope of the pond between the Lower Falls and Waltham, and have margin enough to provide for the ordinary rainfalls during the dry months. It is recommended that such action be taken as may be necessary to procure an agreement or legislation which shall ensure the maintaining of the water surface within one foot of the top of the flash boards, except in cases of accident or special repairs requiring the drawing off of the pond. As soon as this is accomplished the amount of exposed land surface during the dry times is greatly reduced, and the problem very much simplified. Similar arrangements should be entered into with the upper mills at Newton Lower Falls and Newton Upper Falls.

Improvement of Banks.

Different styles of treatment involving varying expense should be adopted for different portions of the banks, adjusting the method to the special location.

There are a number of sections which are nearly land-locked and can be diked off at reasonable expense thus maintaining the water surface at such a height as will prevent the exposing of the bottom when the river falls much below the standard height.

It is not advisable to close any sections in this way unless provisions can be made for artificial circulation and renewal of the water in the basin.

Inlet and outlet channels should be provided at opposite ends of these sections controlled by the tide-gates, or otherwise in such a way that when the river is rising, the water is admitted at one portion of the section, and when the river is falling, it is discharged from the other section. In this way a circulation is maintained, which although not rapid, should be sufficient to prevent the water from becoming stagnant.

In some portions a drainage area exists, which furnishes enough in flow to materially assist in preventing stagnation. The section near Cram's Island at the Waltham line is possibly the most prominent of all this class of areas.

There is another class of areas requiring treatment which cannot be diked off and are still land-locked in such a way that the current of the river cannot be used for their improvement. Portions of these should be treated with a light fill, carrying the surface above the ordinary fluctuations of the river, and protected against rapid current by the planting of trees at the upper end of the construction of such embankment as may be desired. The material for this fill can be taken from sections lying just below the standard surface and deepening the water over them enough to improve the character of the area. This, however, should not be resorted to in any localities where any danger to the public health would be feared from the disturbing and exposing of this material.

For these sections, the work should be done entirely by filling, and filling will be the cheapest in many cases where the strip to be treated is narrow and the bed of the river fairly deep within a short distance of the shore.

The sections that lie between high and low water marks, and are exposed to the force of the current during freshet times, can be improved in some cases by cutting off the bushes and grass for three or four years in succession, and allowing the current to scour off the surface material which has accumulated on account of the retarding of the current.

This in some cases can be assisted by a light floating boom extending below the surface and provided with wings which deflect the current towards sections to be removed. The treatment of these areas along the river should be taken up and carried through in connection with the construction of the parkways, and other improvements which are desirable for other reasons beside the mere improvement of the river bed. If done in connection with these improvements it is practicable to use the material taken from bluffs in constructing the parkways, for the grading up of low sections lying close to them.

The details for the treatment can only be decided upon with best economy by a comprehensive study of all the points involved both in relation to the improvement of the river and the construction of the parkways, etc.

Upper Charles River Section.

This section includes the portion of Newton near the

Brookline Line, and bounded by water sheds near Winchester and Dedham Streets.

The brook near Nonantum Street furnishes the principal waterway, and its development is not required at present, so that no study has been devoted to this section, and it is simply necessary to protect the rights of the city in the present waterways against future encroachments for building purposes.

The Laundry Brook Section.

The Laundry Brook valley includes portions of Wards one, two, and six, and is bounded by a water shed near the following streets: Jewett St., Mt. Ida St., Bellevue St., Centre St., Park Ave., Cotton St., Waverley Ave., Ward St., Clinton Place, Mill St., Hull St., Murray St., Otis St., Lowell St., Watertown St., Broadway, California St., Bridge St., and Watertown St.

The principal line for this section will follow the present channel of the brook to the junction near Harvard Street and a new route from Bulloughs' Pond.

The lower end of this line is in Watertown, and the water is used in Morse's Pond and Boyd's Pond for power and other purposes at the factories. Morse's Pond is entirely in Watertown, and at so low a level as not to effect the question of Newton's drainage. Boyd's Pond lies partly in Watertown and partly in Newton, and is an artificial pond, made by a dam at Morse Street. It is already a source of complaint due to the varying heights of the water surface from the uses of the water at the mill, which exposes the bottom and sides of the pond.

It is probable that ultimately this pond must be discontinued by the removal of the dam. This will be more necessary in the future than at present, as the flow in the brook is becoming every year more and more irregular, causing higher water during freshet seasons, and consequently more overflow from the brook immediately above the pond.

Between this pond and Walnut Street, the brook flows through a section which lies low as compared with the present surface of the brook, and the value of the land along the brook for building purposes is much lower on that account, than it would be with proper drainage. It is perfectly practicable and advisable to take land for a park along nearly the entire length between Pearl Street and Cabot Street at Blake Street. The width so taken can be varied to suit the ownership of the land, and to provide for the satisfactory cutting up of the land for building purposes. Then the city can lower the brook by excavation on its own property, and can provide for the proper drainage of the section, which is required, the increase in value of the property from the construction of the park, and from the thorough under-draining of the land being much in excess of the land damages and cost for drainage.

The entire portion of Newtonville east of Murray and Walnut Streets depends for its drainage on Laundry Brook, and in a number of places the grades are so flat as to require large sized drains in order to convey the heavy rainfalls with the brook at its present height.

The northerly portion of this water shed is drained by the "Central Avenue Drain." This controls the elevation of the storm water level on the section bounded by Court Street, Central Avenue, Watertown Street, Adams Street, and Washington Street. It is now carried about as low as practicable until the main channel of Laundry Brook is made deeper. Through this section, open channels along a right of way sufficiently wide for all future improvements that are needed, are probably more satisfactory. The requirements in this drain is depth, but the nature of the ground is such, that an excavation of considerable width must be made in order to provide for the required depth without too frequent repairs and cleaning out.

The southeast portion of this water shed is drained by a brook crossing Cabot Street, Centre Street and Cotton Street.

This brook runs through unimproved land, and land now used for farming purposes or private grounds, and for quite a portion of its length is at the bottom of a sharp valley, where there is no objection to its present surface. On a portion of its length, however, it should be lowered. This section could be easily adapted for park purposes, and would furnish a very convenient route from Newton Centre to Newtonville with easy grades, and would open a fine section for building purposes.

The present route of the main brook above Cabot Street, is through a section that is being rapidly built up with houses, placed so that their basements are close to the high water line in the brook.

The present brook channel does not accommodate the present storm flow of the brook, and the final building up of the water shed above it, which extends to Chestnut Hill and Waban, will increase the flow far beyond the present capacity of the channel.

If we attempt to enlarge the present channel to accommodate this flow, we find that the extra width required for either brick or stone construction would be expensive to purchase, and the value of the land is such that we should be excluded from considering the question of the open channel, and the cost is excessive with either brick or stone.

Studies have been made to consider the question of other routes for this water. The question of diverting it to Cheese Cake Brook through Murray Street has been examined, but the cost for the right of way and excavation for the brick drain is large enough to exclude this route, which would also have the further complication of claims for water damages from the mills on the brook at Watertown.

Another route has been examined which would involve a new channel from the northeast corner of Bullough's Pond to the east branch of the brook near Blake Street. It can be constructed and maintained as an open channel without injury to the adjoining property. The required excavation is apparently easy to handle, and can be made without any extra expense from the presence of the water. There are no indications of ledge at any part, and the material excavated can be used for the improvement of some of the low land in the immediate neighborhood, or can be carried by gravity for the park suggested below Cabot Street.

By taking a section from 100 to 400 feet wide for a park along the route, we shall have another link in the chain of parks, and a convenient drive from Newton towards the Cemetery and Newton Highlands, connecting with Washington Street near Adams Street.

The benefits to the adjoining property from the park, would offset a large portion of the expense, and the problem of the future waterway from Bullough's Pond to Newtonville Avenue, would be solved in a very satisfactory manner.

The water rights at the dam in Bulloughs' Pond may enter into the question of route for this water, and must be considered later in connection with the question of treatment around Bulloughs' Pond, which will be taken up in connection with the treatment of the Hammond Brook valley. The treatment of the other portions of this water shed involves no special engineering problems, and will be easily handled if care is taken to provide for an ample lowering and improvement of the main line below Cabot Street.

Hammond Brook Section.

This section is bounded by water shed lines near the following named streets: Prospect Ave., Murray St., Walnut St., Beacon St., Institution Ave., Boylston St., Ward St., Mill St.

The treatment of Bulloughs' Pond is one of the most important points in connection with the discussion of this section. The present water surface is maintained by flashboards standing twenty to twenty-four inches above the height of the permanent crest of the dam. This has flooded a section near the corner of Homer and Walnut Streets and interferes with the under-draining of quite a section in addition to that actually submerged. This condition cannot be considered as condusive to the public health. A change in the water surface and also in the surface of portions of the surrounding land must be made before the treatment can be considered satisfactory or permanent.

The banks for a pond of this character should have clean, sharp, well-defined slopes of gravel or similar material, and rise at least two feet above the usual surface of the water in the pond, and more than that amount if to be used for residences. The exact treatment at the upper end of the pond will depend upon the final development, but in general, the low portions should be excavated to at least two feet below the low water mark finally adopted for the pond, and the material taken out placed upon adjoining sections, so as to bring them to at least two feet above the standard surface of the pond. It is probably best to use the crest of the permanent dam as it stands at present for the standard water-surface of the pond, thus lowering the water table under the section at the upper end of the pond, which may now be considered as dangerous to the public health.

After the treatment of Bulloughs' Pond has been adopted practically as outlined above, the treatment along the banks of Hammond's Brook and of Cold Spring Brook, become comparatively simple as the lowering of the surface in the pond provides sufficient grade for satisfactory treatment.

The section of Hammond Brook above Bulloughs' Pond should be treated for a greater portion of its length as an open channel maintained in connection with parkways and the playground.

The section from Centre Street to Beacon Street, or possibly Glen Avenue, is through property where it is doubtless desirable to maintain a covered drain. Probably a portion of this section will be rebuilt in the public streets in the future, and discontinued on the private land.

The section above Glen Avenue lies through a territory of little value at present, compared with its possibilities as soon as the brook is improved, and a parkway or forest should be reserved along the entire length of this part.

Hammond Pond, which is the source of this brook, should have the banks improved in places, part of the improvement should probably be effected by altering the water surface and then treating the low sections around the shore in the same general method as outlined for Bulloughs' Pond. The branch brooks in this section present no special engineering problems, the branch near Irving Street to Grant Avenue being the principal one. This section is being rapidly developed, and drains of ample capacity should be provided at an early day.

Cold Spring Brook Section.

This section is bounded by a water shed line near the following streets: Valentine St., Fuller St., Chestnut St., Woodward St., Forest St., and Walnut St.

The level of this brook is controlled by small dams which create ornamental ponds in the Newton Cemetery, and does to a certain extent prevent the lowering of the water level over that portion of the water shed on each side of Beacon Street West of the Cemetery, and that portion south of Beacon Street known as Cold Spring Swamp, which includes about 100 acres of peat meadow, surrounded by sharp slopes.

By deepening and enlarging the east branch of the brook leading from Cold Spring Swamp this section can be drained without materially interfering with the supply of water to the ponds in the Cemetery. But in order to thoroughly drain the west section it will be necessary to lower the level of the ponds and deepen the brook.

The drainage of this district can be greatly improved, and the water level sufficiently lowered for agricultural purposes by opening up, widening and deepening the brook, so as not to affect the water-level in the ponds as at present controlled.

Lower Cheese Cake Brook Section.

This section includes portions of Wards two and three below the Boston and Albany Railroad, and is bounded by the water shed line near the following streets: California St., Broadway, Lowell St., Murray St., Highland St., Temple St., Putnam St., Boston and Albany Railroad, Auburndale Ave., Sheridan Ave., Derby St., Waltham St., Crafts St., and North Street. The remaining portions of the water shed being treated later as the Upper Cheese Cake Brook Section. The lower section is drained by one principal line and has two branches, the Murray Street line entering it from the southwest, near Eddy Street, and the Cherry Street line entering it from the northwest at Waltham Street.

The portion of the waterway between the Charles River and Watertown Street is now being treated in accordance with the general system recommended in this report for the parkways, and may be examined upon completion as an illustration of the style of construction recommended for that work. The detail, of course will be modified to suit the topography at different portions of the city.

The width of taking is about 120 feet, and two roadways are constructed each thirty-two feet wide, including the sidewalks and leaving a parkway between them fifty-six feet wide. From eight to twelve feet of this is used for ordinary flow of the brook, and has banks with flat slopes extending up to the roadway and forming a channel for the flow of the brook during freshet times.

It is expected that the flow over the banks will be gentle enough so as not to disturb the grass after it has obtained a thorough hold on the soil. Of course, at times, small repairs may be needed in common with those required for every other style of construction.

The estimated cost of this section for its entire length is about $5.00 per running foot, of which $1.80 has been allowed by the sewer department as a portion of the saving to them from the reduced expense, due to construction in connection with that of the parkway and the lowering of the brook. The net cost for improvement to the channel and roadways is consequently only $3.20 per running foot, exclusive of any allowance for land damages. It is expected, however, that the benefit to the property will offset the amount of the land damage, and the increased valuation will furnish ample recompense to the owners, while the increased taxes will reimburse the city for the small expense incurred, compared with the advantage derived. It is to be regretted that a similar treatment could not have been provided in the previous street layouts, so as to extend the advantages to Waltham Street, which are now derived, as far as Watertown Street, at the lower crossing of the brook.

The treatment to be adopted for the section from the lower crossing at Watertown Street to the Boston & Albany Railroad near the Washington Street crossing, depends upon the volume of the water which must finally be provided for through this section.

Ample waterways could be provided at reasonable cost through most of the section below Waltham Street, although seven streets are already laid out across the brook involving extra expense at these crossings, for each change in capacity, and the section is building up rapidly and increasing the damages for any change or takings of land for the purpose of increasing the waterway.

Above Waltham Street, any change must be made at a serious expense, on account of the proximity of the buildings, and the high cost of land for an additional width.

The construction would also be expensive, as it would necessarily be of the best quality, and must be carried on with provisions for taking care of the flow of the brook during construction. For these reasons, the question of other outlets for the water from the upper part of the valley has been thoroughly examined, on account of the large saving which would result from any methods which obviate the necessity for enlarging through the West Newton Village.

The most favorable route is from a point near the junction of the main brook with the Auburndale branch, and passes across private land west of Webster Park through Auburndale Avenue, and through the city land and private property by Pine Street and Lexington Street to the Charles River.

This section is almost entirely through land that is of no use at present, as no crops whatever are raised along a large portion of the route, and considerable of it is through marshy ground, unfit for any use at present. The selection of this route also furnishes a highly satisfactory outlet for the Cherry Street Section, whenever the requirements exceed the present capacity of the outlet through River and Waltham Streets.

Between the present channel and Pine Street the betterments should be in excess of the land damages. Beyond Pine Street, the section is already overflowed, and is probably held subject to flowage by the dams at Waltham, and the construction of an ample culvert at Lexington Street would prevent any raising of the present surface from the additional water coming from Cheese Cake Brook. If this outlet is constructed, the present channel of Cheese Cake Brook is ample for all requirements for many years.

The Murray Street branch will be effected by the final decision in connection with the separating of the grades at the Railroad Crossing.

The best method for construction between the Railroad and Otis Street is by means of a brick drain, as the grade available is small, and it is desirable to prevent the filling of the ground by the water from the upper end of the valley. There is an opportunity for releiving this section with but little expense, by diverting a portion of the flow to the Laundry Brook Section, and the flow above Otis Street can be so diverted, if the development adopted for the Laundry Brook Section will permit.

The Henshaw Street section and the Cherry Street section have until recently been a source of a good deal of complaint. An outlet has been constructed for the Henshaw Street section passing through River and Waltham Streets to Cheese Cake Brook. This outlet is of sufficient capacity to provide for the wants of the section for a number of years, and it also reduces the annoyance on the Cherry Street section. This treatment of the latter, however, cannot be considered as ultimate, and the plans as submitted show a line from these two sections to the side outlet of Cheese Cake Brook. The sizes shown are ample for the treatment of the whole section, and it is probable that when the construction is done, somewhat smaller sizes than these will be deemed satisfactory. The outlet indicated affords full relief to the section in question. It may be desirable to secure the rights of way before the improvement of the territory shall interfere with them.

There is no special engineering problems connected with the rest of the Lower Cheese Cake Brook section.

Upper Cheese Cake Brook Section.

This section includes portions of Wards three and four, and is bounded by the water shed line near the following streets: Putnam St., Temple St., Valentine St., Chestnut St., Beacon

St., Washington St., Aspen Ave., Unity St., Grove St., Auburndale Ave., Melrose St., Central St. It may be divided into three sub-sections that require special attention in connection with the drainage.

The first section is along the main brook between the Boston & Albany R. R. and Myrtle Street. Through this portion it will be necessary to provide a large waterway in the future, as the entire flow from above must be cared for. The treatment must suit that of the grade crossing problem and must be studied in that connection.

Above Myrtle Street, arrangements can be made for providing a waterway ample for all requirements, if a right of way is reserved sufficient to permit the enlarging of the brook as needed in the future, and I think this can be maintained permanently as an open brook with a parkway near the upper end. The steeper portion of the brook can be treated with good effect, with a series of ponds and waterfalls.

Most of the valley has steep slopes to the brook, but there is a circuit around Wyman's Hill where a deepening will be necessary before the land is available for building purposes.

The next section is the portion of Auburndale near Auburn and Maple Streets. This section would be greatly benefitted by a deepening of the brook, and this will be possible as soon as a change has been made in the main channel. The drain through this portion passes through private land above Auburn Street, and can be deepened and widened to meet all requirements if the rights are secured at present before the land is brought into the market.

The remaining portion that requires special consideration is the valley north of the Railroad and extending from Webster Street to Melrose Street. This section only requires a small lowering of the water-table to open it for building purposes along a considerable portion of its length. One or two portions are boggy and may require cleaning out, but nearly the entire section can be made available for building purposes by means of this change.

These points cover the most interesting engineering problems connected with this section, and the whole development hangs upon the lowering of the main line. When this is accomplished, fair grades can be obtained on the main branches, and the necessary sizes reduced to correspond.

South Meadow Brook.

This includes portions of Wards five and six, and is bounded by waterways near the following streets: Oak St., Pettee St., Boylston St., Woodward St., Lincoln St., Lake Ave., Beacon St., Institution Ave., Dudley St., Brookline St., Dedham St., and Winchester St. The lower portion of this brook forms the Mill pond at Pettee's Machine Shops.

The treatment of this section near its lower end hinges upon the decision of the questions introduced by the mill pond of the Pettee Mfg. Co. As long as this pond is maintained at its present standard height, there exists a large section of land partly or wholly submerged, and with the water-level very close to surface on the other sections, rendering them unfit for building purposes and dangerous to health. The removal of the mill pond would improve the land above it, and permit the thorough underdraining of the valley for its entire length. The rights for maintaining the mill pond are persumably well established, although it has not been deemed necessary to examine this point at the present stage of inquiry. The injury resulting to the mill owners, if any, from the loss of this pond, is that due to the taking away of the water power.

The mill pond is not sufficient in size to store the flow of the brook during the wet portions of the year, which is becoming each year more intermittent, and at best supplies but a very small portion of the power required to operate the machinery of the mills.

The question of damages by reason of the taking away of the mill pond, is also effected by the extra care and inconvenience due to maintaining both a water and steam plant, and other considerations which tend to reduce the apparent advantage from the water power as long as nothing is done which reduces the amount available for boilers and manufacturing purposes. The actual flow of the stream will be increased rather than diminished, from the fact that the evaporation which at present must reduce the outflow very decidedly, will be almost entirely done away with, by deepening the channel, and the lowering of the water surface. The question of whether the entire pond shall be removed, or whether it shall be lowered to about elevation ninety-six or ninety-seven, is one which can best be settled in conference with the mill owners. It would appear, however, that a reasonable price could be decided upon, satisfactory to both the city and the owners, for covering the apparent loss to them from the taking away of the use of the water power.

The question of damages is on a different basis from what it would be if the mill was situated at a distance from other sources of water, and the entire flow was cut off, instead of being increased, and also different from what it would be in the case of a mill having water supply equal to their requirements during quite a portion of the year, thus enabling them to run without steam power.

The section above the pond on the main line would be open for building purposes on many portions of its extent as soon as this drain was completed.

The portion near Newton Highlands and Newton Centre can also be drained at small expense. All of this portion can be drained by means of open brooks, and the laying out of parks or reservations through these portions is desirable, although not a necessary part of the plan.

For the portion of this territory near Jackson Street there are no immediate requirements for new construction, except possibly occassional culverts under a street, and the only steps necessary in this section are the providing for the rights of way that will be needed for the future improvement of the channels.

Boston Section.

The Boston section includes a small portion of Wards seven and six, and is bounded by Kenrick Street, Waverley Avenue, and Hammond Street. The slope of this area is towards the City of Boston, and the waters falling upon it will have their ultimate outlet in a brook leading from Strong's Pond, or in a drain laid about Chestnut Hill Reservoir, in the City of Boston. When necessary, it can be provided for by covered drains, laid from such streets as may be laid out in the territory in the future, it being at present undeveloped. On this account a detail study providing for this district has not been made.

Benefits and Assessments.

One of the important questions to be considered, is the date at which work should be done, and also the method of payment for the same, and it may be perhaps interesting to inquire as to whether it can be considered a good investment for the city, or solely a penalty for unfortunate topography.

The improvements are made necessary by the fact that there is a large portion of the city which is at present poorly drained, or too low to be built on, and we also find that through most of these sections a lowering of the channel of the waterway from two to five feet would bring most of the property into condition available for building purposes.

The advantages from this change would result,

First: To the city at large, in the improved reputation for good drainage and healthful surroundings, also in the increased valuation of the land and the increase in taxable property, both in the buildings erected, and also in the personal property brought into the city from the increased number of residents.

Second: To the owner of the property, both that which is sub-drained, and also that which is near enough to the other to have been previously effected by it, either by the vapor rising from it, or by the influence of the low section on the general tone of the neighborhood.

Third: To all of the property owners in Newton, from the increased market value of their property by the gain resulting to the reputation of the city as a healthful dwelling-place.

The first and second of these improvements are tangible in their nature, and the value of them can readily be appreciated, and the third is equally true, although possibly not as prominent or as well defined.

The benefits are thus seen to extend to all of the property holders throughout the city, but are more especially felt by those in the immediate vicinity of the sections that are improved; and the source from which the money should be derived should correspond to a considerable extent with the distribution of the benefit, and some system adopted by which part of the cost is borne by the city and a part by the owners of the land visibly benefitted.

The question as to the date of construction is important as far as effecting the consideration of the subject, and an examination of it from the standpoints of finance and health will result in the conviction that it is judicious for the city to expend a reasonable amount each year for the proper carrying forward of the system, care being taken that whatever work is done, is done in such a way as to form a portion of the complete system later.

The financial advantages may be considered as covering the following points:—

First, parties seeking homes will naturally turn towards cities in which progress is being made in the direction of correct drainage, so handled as not to be burdensome at the time, but so as to ensure gain from year to year in this direction.

Second, many sections can be developed at a much lower cost by the lowering of the waterway, and this enables the owner to improve the property by this method, when otherwise, any action of that kind would involve so much expense that it must be postponed for years on that account.

Third, the expense incidental to the cost of rights of way and changes of location through thickly settled portions would be reduced if the work should be carried out through the various sections before the actual work of developing is commenced.

The advantages to health will be felt both in the sections that are underdrained or have the water table lowered, and in the sections close to them, which, at present, are effected to a considerable extent by the vapors rising from them.

The land owner is interested in this question financially, as he is waiting for a purchaser for his land at perhaps three to ten cents per square foot, while he sees his neighbor dispose of his land at twenty-five to fifty cents per square foot, and there is only one reason that he can assign for the difference. He cannot afford to make his land equal to the other by grading up, and is perhaps hindered from improving it by lowering of the drain, from the fact that he cannot arrange for concerted action on the part of all owners effected, and does not feel equal to the expense of undertaking the whole of the improvements himself. If the city will act as the middle party for procuring these changes, he can well afford to pay his assessments out of the increased price of his property, due to the change.

It would seem desirable that the work be entered upon at an early date in order to avoid the increased expense due to the attempt to carry out the improvements after the sections are built on, and the routes that are most desirable are across small estates with numerous owners, each of whom feels that his rights are being interfered with whenever any attempt is made to change or improve the waterway.

Another reason for immediate action is the fact that the lowering of the waterway makes a large saving in the cost of developing many of the sections, and enables the owner to bring them into the market, whereas otherwise, action of that kind would involve so much expense that it would be postponed for years on that account.

A third reason that can be given is the fact that there is a rapid growth of the population in the vicinity of Boston, and that it is necessary to offer inducements in the matters of drainage and sewerage to induce the best class of people to settle in any city or town. Viewed from the standpoint of investment, now offered, and attractive enough to justify the city in borrowing such amounts as are needed to carry forward the improvements at a reasonable rate, some portion of the work being completed in each year. Provision should also be made for obtaining such protection to the rights of the city as are required for the economical location and construction of the waterways.

Parkways.

It has been found necessary to give more or less attention in different parts of the city to the question of suitable routes for parkways, in order to make sure that the routes shown for the drains were those ensuring the best advantage to the city.

A plan is submitted herewith showing the results of these examinations as far as they have been deemed worthy of record. The question has been examined somewhat in other sections of the city beyond those shown, but the time of development and its probable character have been so uncertain that it was not deemed advisable to attempt to define exact locations. The treatment shown should be regarded as suggestive only, and should not be used as a substitute for the more thorough and formal report which will be made later by the Boulevard or Park Commission recently appointed. The lines shown, extend in some cases, somewhat beyond the actual requirements for drainage purposes, in order to call attention to the symmetry and completeness of the system, which would not appear if the short connecting systems were not shown. Beacon Street, and Washington Street and Fuller Street, Homer and Grafton Streets and an extension of South Street from Ward to Centre Streets have been indicated as a portion of the Park System, for this reason, although surface drainage requirements do not call for it, except possibly in short portions of its length.

Co-operation.

The success of the attempt on the part of the city to provide the system of Surface Drainage and Parkways recommended in this report, will depend to a great extent upon the co-operation of the owners of the estates effected, and upon their willingness to consult with the city authorities, and make in some cases, small sacrifices for the general good. There is not a single section in which a parkway is indicated where the construction is not felt to be of pecuniary advantage to the land owners. It is however true, that the advantage to the individual owners is very small in some cases, and an equitable adjustment is needed to offset this against the large advantage occurring to other owners in the same section. This can often be adjusted to better advantage by private individuals than by the city.

Legislation.

On the question of legislation or other method of obtaining rights by the city to construct drains through sections that require them, and also to enable the city to use the most economical route for drains, it appears to us to be desirable that a radical position should be taken in this matter, and every legitimate method used to establish rights on the part of the city for doing such work, and being able to accomplish it at a reasonable expense.

As matters stand at present, a land owner grades out or encroaches upon an old water way and distributes the water over the surface of the ground in connection with any change he may see fit to make in his property.

After a few years have passed, a request is made for drainage and it is found that the city must either use a route through the street at additional expense caused both by length and extra depth of cutting, or else it must pay to the land owner the exhorbitant price for right of way through his property.

It would not be expedient or just to demand legislation taking away any legitimate and proper rights of a land owner, and on the other hand, it is not right for the city to be obliged to add twenty-five or more per cent. to the cost of their drainage system for the mere purpose of respecting the rights which are such only in theory, in many cases, and not rights in equity.

It may be too late to save money to the city in the most thickly settled portions, as the waterways and drains are already well established in the private lands or are placed in the streets, but there are surely many portions of the city where the water courses are being covered up and reduced to extremely small dimensions, or in other cases entirely obliterated by grading and by use of dry wells, which carry the surface water into the ground and allow it to find its own outlet.

The equitable arrangement is for the land owner to be able to demand that the city shall provide suitable drainage to ensure his property against damage by floods or underground water, but on the other hand be prevented from making an unreasonable charge to the city for the use of land for the purpose.

The City of Boston has obtained legislation enabling it to establish a Board of Survey, who are authorized to lay out streets and to designate what locations and grades are to be, and prevent the owner of the property from making any other treatment. If this action is justifiable, there is much more ground for authority for a city to lay out and determine the size and location of their surface drainage and prevent interference of the same by property holders and also be subjected to damages when they shall cause it. Such a law would effect a saving in the ultimate cost of the construction of the drainage works, one hundred thousand or more dollars.

This is a matter that underlies the whole scheme for the drainage of the city and is being complicated all the time by the changes in the nature of the property through the laying out of new streets and their consequent house lots.

There are at present many miles of valleys in the city through which the water has flowed for centuries. These valleys are the natural water routes for the drains, and any departure from them is at the expense of the city.

If authority should be given to proceed in such a way as to control the layout of the streets so that they would conform to the convenient and economical drainage of the land, balancing it of course against the other interests involved, it would be a matter of great economy to the city and would also result in very much better property for the use of the owners.

CITY OF NEWTON.

SUMMARY.

The conclusions and recommendations of this report may be briefly summed up as follows:

A. The style of construction should be determined with reference to the cost with little regard usually to the question of water-tight work.

B. The early construction should be laid with a view to securing depth of drainage, rather than simply carrying capacity.

C. New sections should be improved by lowering the drains rather than by grading up the land.

D. This course gives a saving to the land owners larger than the cost of the improvement of the water way.

E. Open construction through parkways or reservations should be adopted except through high priced localities or under special circumstances.

F. These waterways should be treated so as to be ornamental rather than a detriment to the surrounding property.

G. The construction of a chain of parkways between the different villages would afford the most economical location for the drains and house sewerage pipes.

H. The effect upon the growth of the city justifies action upon at least a portion of the recommendations.

I. The construction adopted should be such as to admit of enlargement, at reasonable expense, from time to time.

J. Co-operation on the part of the land owners, or what might be styled "self assessment," would greatly facilitate the execution of this work.

K. The rights of the city in the existing routes should be defined and protected.

L. Desirable routes for future construction should be selected, and guaranteed to the city.

M. The borders of the Charles River should be improved at an early date in connection with other desirable improvements.

N. Agreement with the mill owners should be obtained guarding against the unreasonable lowering of the water surface in the river.

O. A new route should be provided for Laundry Brook from Bulloughs' Pond to a point below Cabot Street, and the water surface of the pond should be lowered from its present height.

P. A side outlet should be provided for Cheese Cake Brook from Webster Street, Boston & Albany R. R., to Charles River at Lexington Street.

Q. The Pettee Mill pond at Newton Upper Falls should be lowered to provide for the better drainage of the South Meadow section.

R. Boyd's Pond should be lowered and the brook confined to its original channel by the removal of the dam at Morse Street.

S. Such legislation as is necessary to define and secure the rights of the city in existing waterways and reasonable locations for future waterways should be secured.

T. Such legislation as is needed to reasonably control and direct the layout of streets and private ways should be secured.

Respectfully submitted,

ALBERT F. NOYES, *City Engineer*,

AND

EDWARD A. BUSS.

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